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August 16, 2000

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Washington, DC 20231

Presented for filing is a new original patent application of:

Applicant: JABE A. SANDBERG AND DMITRII LOUKIANOV

Title: IMPLEMENTING CABLE MODEM FUNCTIONS ON A HOST COMPUTER

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Enclosed are the following papers, including those required to receive a filing date under 37 CFR 1.53(b):

	Pages
Specification	10
Claims	4
Abstract	1
Declaration	3
Drawing(s)	4

Enclosures:

— Assignment cover sheet and an assignment, 2 pages, and a separate $40 fee.
— Postcard.

There are 18 total claims, 3 of which are independent.

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Basic filing fee	$690
Total claims in excess of 20 times $18	$0
Independent claims in excess of 3 times $78	$0
Fee for multiple dependent claims	$0
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For Scott C. Harris
Reg. No. 32,030
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Attorney's Docket No.: 10559/223001 / P8788

APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: IMPLEMENTING CABLE MODEM FUNCTIONS ON A HOST COMPUTER

APPLICANT: JABE A. SANDBERG AND DMITRII LOUKIANOV

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IMPLEMENTING CABLE MODEM FUNCTIONS ON A HOST COMPUTER

TECHNICAL FIELD

This invention relates to cable modems, and more particularly to migration of functions from a cable modem to its host computer.

BACKGROUND

With the recent rise in popularity of the Internet, many home computer users are using a modem to access the Internet through the Public Switched Telephone Network ("PSTN") using home telephone lines. The PSTN provides a dedicated circuit from the modem to a server located at an Internet service provider. The server functions as a gateway to the Internet. However, the bandwidth of typical home telephone lines is relatively small, which limits the speed that information can be received from the Internet.

As an alternative to using telephone lines, the Internet can be accessed through coaxial cables using a cable modem. Coaxial cables provide greater bandwidth than home telephone lines and are widely available to existing cable television subscribers. The greater bandwidth also enables new applications such as telephony-over-cable that are not necessarily associated with the Internet.

Unlike telephone lines, existing coaxial cable infrastructure typically does not provide a dedicated circuit to the home user. Instead, multiple users are usually coupled to the same coaxial cable leading to a server located at an Internet service provider. In addition, television signals are also usually sent on the same coaxial cable. Therefore, Internet or other broadband service providers that use coaxial cables must send and receive both data packets that contain data, and control packets. The control packets provide the computer and the cable modem with information needed to send and receive the data packets, such as what frequency packets flowing out of the cable modem should be transmitted on, what should its transmitter power level be, how many packets may be transmitted, what data packets on the coaxial cable are intended for the cable modem, etc.

Known cable modems typically have associated with them specialized processors, memory, and software (or firmware) for capturing and processing the data packets and control packets. This specialized modem hardware and software (or firmware) is in addition to the hardware and software within the computer, and therefore increases the costs of equipping a home computer so that it can utilize coaxial cable for broadband access to data services such as the Internet.

DESCRIPTION OF DRAWINGS

Features and advantages of the invention will become more apparent upon reading the following detailed description and upon reference to the accompanying drawings.

Figure 1 is a block diagram of the cable modem host migrated architecture according to an embodiment of the present invention.

Figure 2 is a block diagram of the firmulator of Figure 1 according to an embodiment of the present invention.

Figure 3 is a block diagram of the internal architecture of the firmulator of Figure 2.

Figure 4 is a flowchart showing the process of transferring the cable modem functions to the host computer according to one embodiment of the present invention.

DETAILED DESCRIPTION

Figure 1 illustrates the overall design of a cable modem host migrated architecture. A CPE Controlled Cable Modem (CCCM) Adapter 105 transfers data to the operating system kernel through a PCI Port Driver 110 to a NDIS (Network Driver Interface Specification) Miniport driver 125. The kernel may also include a PCI bus class driver 115. The NDIS Miniport 125 provides for protocol translation, packet queuing, and communication with the Media Access Controller

(MAC). The NDIS wrapper 120 surrounds the NDIS Miniport 125. The NDIS wrapper 120 insulates the network card drivers from protocol drivers and at the same time hides certain details of the hardware platform on which the driver is run. The NDIS Miniport 125 interfaces with higher-level drivers and communicates with a user application such as a web browser 160 through standard TCP/IP interfaces 140 and a socket interface 145.

The NDIS Miniport 125 also interfaces with a firmware emulator ("firmulator") 180 and a diagnostics module 175 through Data Over Cable Service Interface Specification (DOCSIS) abstraction layers 165, 170 and possibly through the intermediate driver 142. The DOCSIS defines interface requirements for cable modems involved in high-speed data distribution over cable television networks. The DOCSIS abstraction layers 165, 170, in conjunction with the NDIS miniport 125 converts hardware-independent functions into hardware-specific functions. This leaves the firmulator 180 universally applicable, regardless of the underlying hardware. Some of the functions performed by the DOCSIS abstraction layers 165, 170 in conjunction with the NDIS miniport 125 include hardware initialization, tuning upstream and downstream frequencies, querying the signal state, adjusting power and timing, ranging request and response, and EEPROM

read and write. Of course, other functions may also be performed by the DOCSIS abstraction layers 165, 170. The NDIS miniport 125 may also interface to the firmulator 180 through the intermediate layer 142 and socket interfaces 150 having helper DLL (dynamic link libraries).

The use of the above items such as the firmulator 180 and the DOCSIS abstraction layers 165, 170 allows functions that were previously implemented in a cable modem to be transferred to the host computer. This eliminates the need for state machines on the cable modem by taking advantage of the hardware and software of the host computer. By executing the state functions on the host computer, devices such as embedded chips (CPU, memory) and software (RTOS and firmware) may be removed from the cable modem. This allows for a lower cost and simpler cable modem design.

The design of the firmulator 180 according to one embodiment of the invention is shown in Figure 2. The firmulator 180 includes a master state machine 200, a SNMP (Simple Network Management Protocol) agent 220, and BPI (Baseline Privacy Interface) state machines 225 besides DOCSIS control state machines 205, 215.

The master state machine 200 may perform many tasks, possibly including receiving, parsing, and routing MAC management messages, maintaining a global database of volatile

and non-volatile data, controlling the DOCSIS state machine functions at a high level, managing execution threads for tasks which must execute simultaneously, providing a central error logging and reporting facility, and interfacing to a user application. The master state machine 200 executes (DOCSIS) startup tasks 300-365 using DAL to translate and communicate with the NDIS miniport driver 125. The commands and data transferred to the NDIS miniport 125 includes modem functions which are converted by the DOCSIS abstraction layer 165. MAC management messages 210 are transferred through one or more socket interfaces 150 to and from the NDIS Miniport 125. The master state machine 200 may also transfer a plurality of IP data 215 to and from the NDIS miniport 125 through the socket interface 150 and the TDI interface 135.

The master state machine 200 also communicates with the SNMP agent 220 and the BPI state machine 225. The SNMP agent 220 is a full SNMP client which manages network management message parsing and execution. The SNMP agent 220 interfaces with the NDIS miniport 125 through the socket interface 150 and the TDI interface 130 and through a DAL (not shown).

The BPI state machine 225 manages threads for per-stream encryption and/or decryption key handling. The BPI state machine 225 interfaces to (or may contain) the

cryptographic function library 230. The BPI state machine 225 interfaces with the MAC management message stream through one or more socket interfaces 150. The intermediate driver may provide for routing of the MAC management messages to particular BPI state machine components. The BPI state machine 225 also interfaces with the NDIS miniport 125 through one or more DOCSIS abstraction layer 165.

The internal architecture of the firmulator 180 is further illustrated in Figure 3. The firmulator 180 includes a plurality of sub-state machines and agents for networking protocols. As defined in DOCSIS, these include startup diagnostics 300, hardware initialization 305, downstream scan 310, get upstream parameters 315, Range 0 320, Range 1 325, a Dynamic Host Control Protocol (DHCP) manager 330, time and date 335, Trivial File Transfer Protocol (TFTP) parameters 340, firmware upgrade 345, registration 350, the BPI manager 225, the SNMP manager 220, and operational and maintenance 365. The state machines execute the DOCSIS modem control engine state machine functions and manage independent processes. Each of the state machines may be implemented as objects to enhance interchangeability. If implemented as objects, the state machines would includes a "run" method for startup and a "do" method for overriding normal process flow.

The state machines interface with the kernel through the DOCSIS abstraction layer 165 or the socket interfaces 150, 150. The startup diagnostics 300, hardware initialization 305, downstream scan 310, get upstream parameters 315, Range 0 320, Range 1 325, registration 350, and operational and maintenance 365 state machines each interface with the DOCSIS abstraction layer 165. The downstream scan 310, get upstream parameters 315, Range 0 320, and Range 1 325 interface through the socket interface 150. The time and date 335, Trivial File Transfer Protocol (TFTP) parameters 340, and firmware upgrade 345, interface through the socket interface 150.

Although the invention is described with respect to a DOCSIS cable modem, it can be understood that the invention is applicable to other cable modems, such as a Digital Audio-Visual Council (DAVIC) modem. The invention may also be implemented over any bus (PCI, USB, IEEE-1394 etc.) and for any operating system.

Figure 4 is a flowchart showing the process 400 of transferring the cable modem functions to a modem function processor on the host computer according to one embodiment of the present invention. The process 400 begins at start state A 405. Alternatively, the process may begin at start state B 407. From start state B 407, the process proceeds to state 440, which will be discussed below. From start state A 405,

the process proceeds to state 410 where the modem function or data is received at the cable modem. The modem function is a hardware independent function generally designed to be processed by the modem.

Proceeding to state 415, the modem function or data is transferred through a driver and/or an interface layer. The modem function and/or data is transferred as required by the operating system.

Proceeding to state 420, the host processor performs calculations on the hardware independent modem function to convert into hardware specific functions. Because the host processor converts the modem functions to and from hardware specific functions, the firmulator may be universally applicable. If the type of hardware changes, only the abstraction layer needs to be changed in the modem function processor.

Proceeding to state 425, the modem conditions are queried through the DAL and the NDIS miniport driver. The abstraction layer may operate in conjunction with a hardware specific driver such as a NDIS miniport driver. The process 400 then proceeds to state 430 where the new modem settings are written through the DAL and the NDIS miniport.

Proceeding to state 435, the results of the function and/or data conversion is transferred through the driver

and/or interface layers to the cable modem or cable modem termination system (CMTS). Therefore, some embedded chip such as a processor and memory may be removed from the cable modem. This allows the cable modem to be less expensive and be manufactured with less components.

Proceeding to state 440, functions may be requested from the CMTS through the NDIS miniport and the cable modem hardware. These functions are then received by the modem in state 410.

Numerous variations and modifications of the invention will become readily apparent to those skilled in the art. Accordingly, the invention may be embodied in other specific forms without departing from its spirit or essential characteristics.

WHAT IS CLAIMED IS:

1. A method of implementing cable modem functions on a host computer comprising:

receiving information which may include cable modem data and cable modem commands at the cable modem;

transferring at least a portion of the information to the host computer;

performing functions corresponding to any transferred cable modem commands on the host computer into first results;

processing any transferred cable modem data on the host computer into second results;

translating the first results into hardware specific functions;

translating the second results into hardware specific data formats;

executing the hardware specific functions; and

transferring the hardware specific data.

2. The method of Claim 1, wherein the host computer includes a cable modem abstraction layer.

3. The method of Claim 2, wherein the translating is performed in by the abstraction layer.

4. The method of Claim 2, wherein the abstraction layer is a DOCSIS abstraction layer.

5. The method of Claim 1, wherein the cable modem functions are performed in a firmware emulator.

6. The method of Claim 1, wherein the modem functions performed on the host computer may be hardware independent.

7. A modem function processor comprising:

an abstraction layer which translates modem functions to and from hardware-specific functions; and

a firmware emulator which performs hardware independent functions.

8. The modem function processor Claim 7, wherein the abstraction layer sends or receives modem commands and/or data to or from a cable modem.

9. The modem function processor Claim 7, wherein the abstraction layer is a DOCSIS abstraction layer.

10. The modem function processor Claim 7, wherein the firmware emulator includes a plurality of state machines and states within the state machines.

11. The modem function processor Claim 10, wherein the plurality of state machines performs the cable modem functions.

12. The modem function processor Claim 7, further comprising an interface to a cable modem.

13. The modem function processor Claim 12, wherein the interface may include one or more intermediate software driver interface layers, such as a transport driver interface.

14. The modem function processor Claim 12, wherein the interface is a direct interface.

15. A method of performing modem functions comprising:

receiving the modem commands and/or data; and

distributing the modem commands and/or data among state machine functions; and

processing the state machine functions on a host computer.

16. The method of Claim 15, wherein the conversion is performed by an abstraction layer which converts between hardware specific functions and hardware independent functions.

17. The method of Claim 15, wherein the modem functions are cable modem functions.

18. The method of Claim 15, wherein the processing uses resources of the host computer.

ABSTRACT

The present invention processes cable modem functions on a host computer. The cable modem receives hardware specific modem functions and transfers these functions to the host computer. An abstraction layer in the host computer receives the functions and converts the functions to/from hardware specific functions. The abstraction layer may be a DOCSIS abstraction layer. A firmware emulator (firmulator) then receives and processes the modem functions. The firmware emulator includes a plurality of state machines and networking protocol agents.

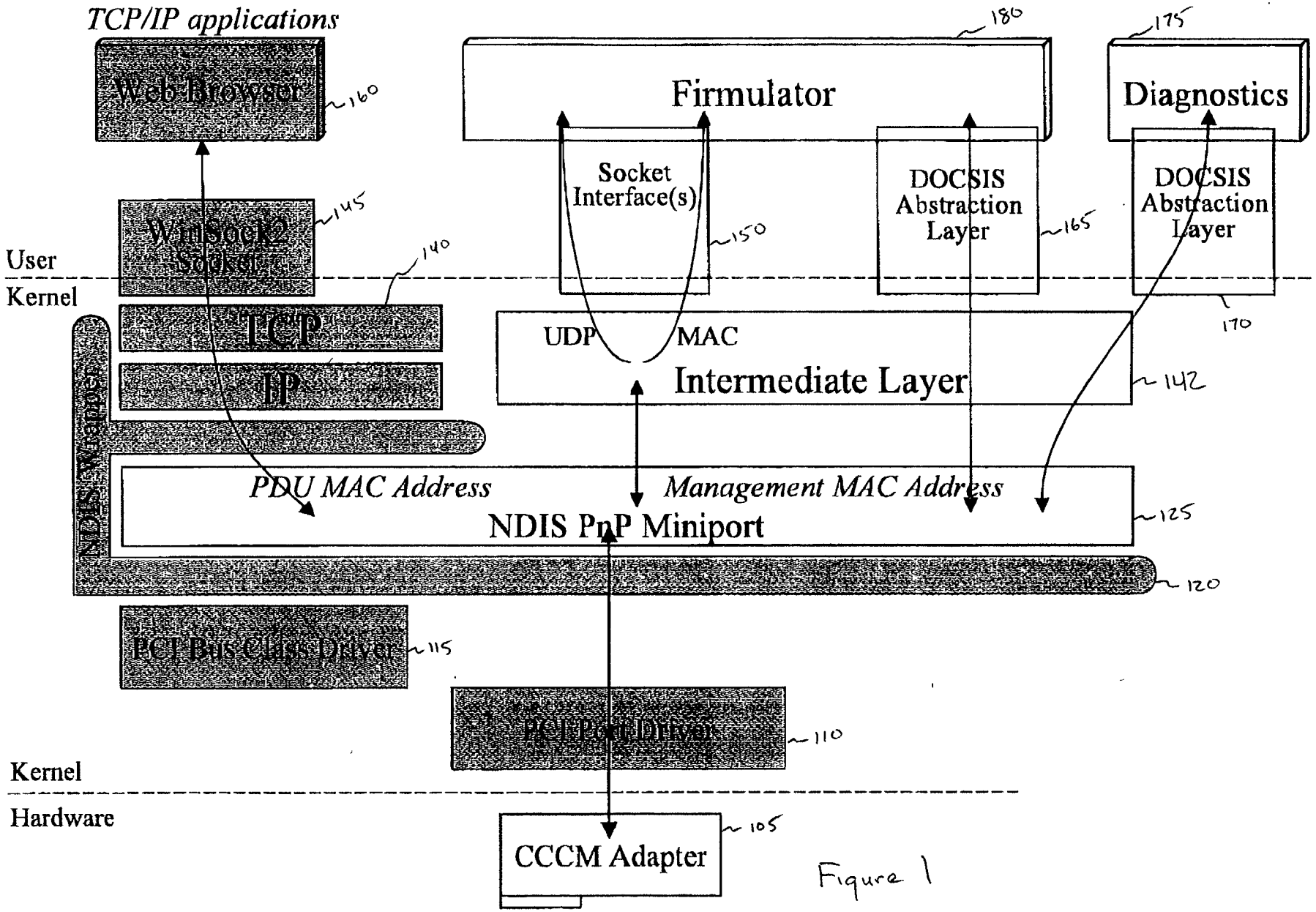

Figure 1

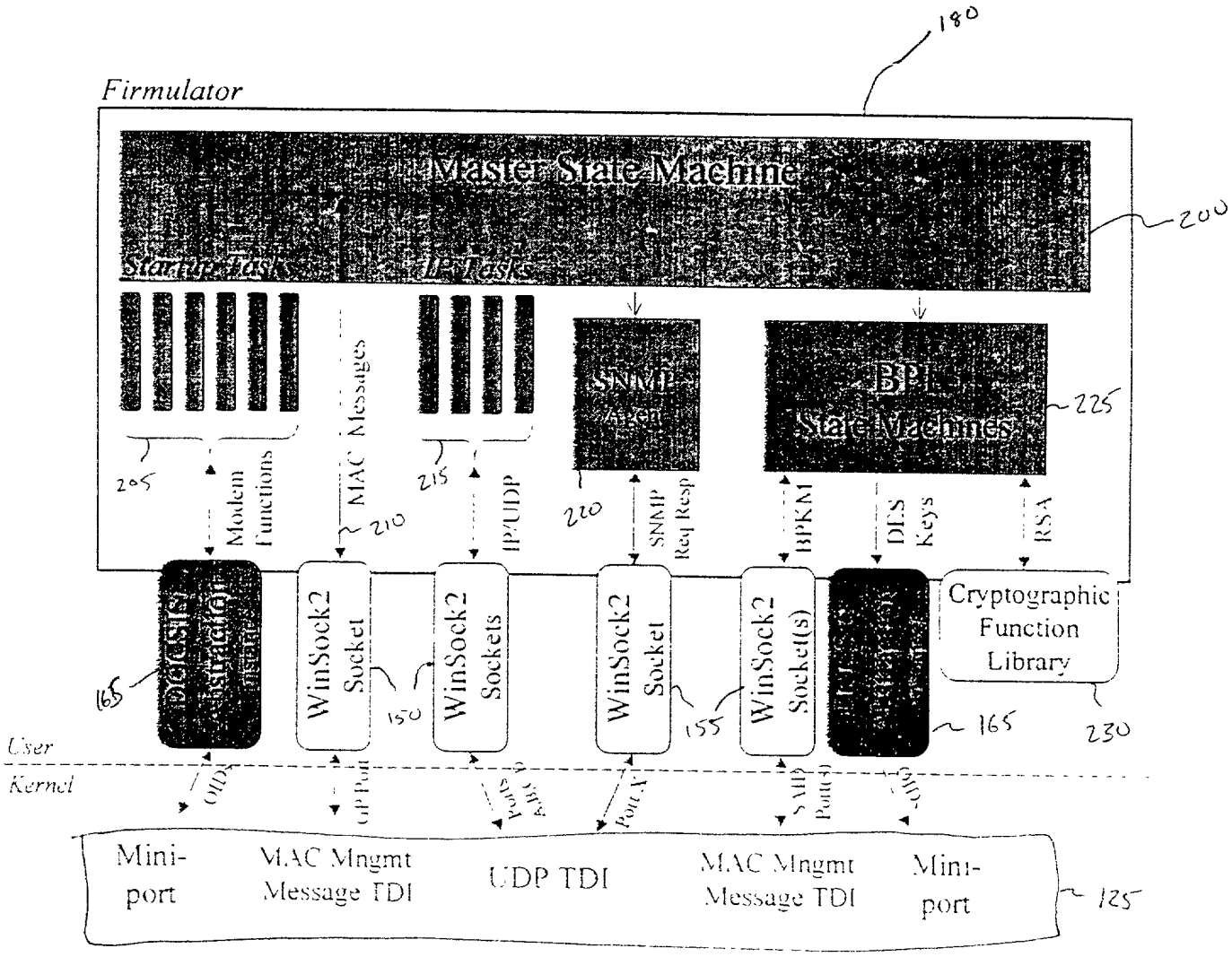
180
Firmulator
Master State Machine
200
Startup Tasks
Tasks
SNMP Agent
BP State Machines
225
205
Modem Functions
MAC Messages
210
215
IP/UDP
220
SNMP Req Resp
BPKM
DES Keys
RSA
Cryptographic Function Library
230
165
WinSock2 Socket
WinSock2 Sockets
150
WinSock2 Socket
155
WinSock2 Socket(s)
165
User
Kernel
Mini-port
MAC Mngmt Message TDI
UDP TDI
MAC Mngmt Message TDI
Mini-port
125

Figure 2

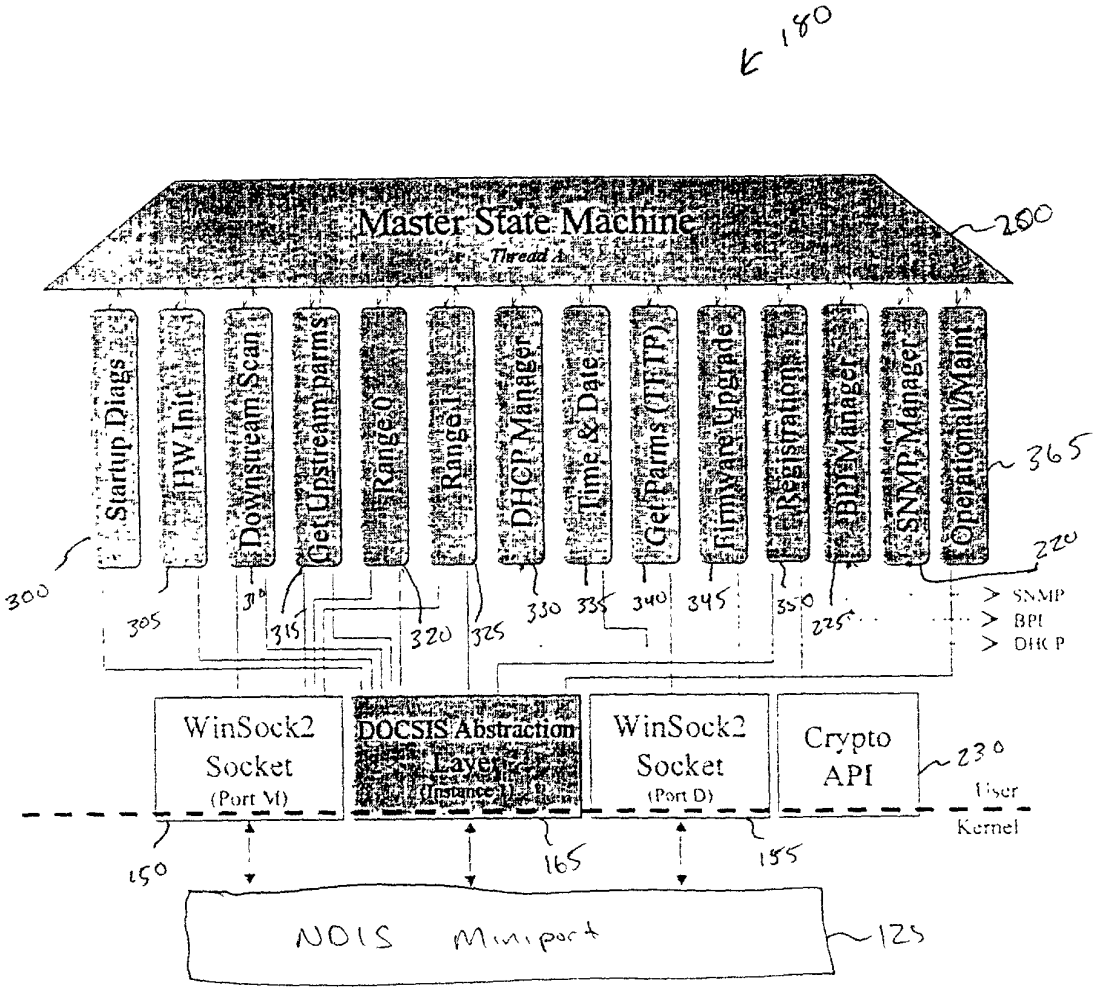
180
Master State Machine
Thread A
200
Startup Diags
HW Init
DownStream Scan
Get Upstream Parms
Range 0
Range 1
DHCP Manager
Time & Date
Get Parms (TFTP)
Firmware Upgrade
Registrations
BPI Manager
SNMP Manager
Operational/Maint
365
220
300
305
310
315
320
325
330
335
340
345
350
225
SNMP
BPI
DHCP
WinSock2 Socket (Port M)
DOCSIS Abstraction Layer (Instance 1)
WinSock2 Socket (Port D)
Crypto API
230
User
Kernel
150
165
155
NDIS Miniport
125

Figure 3

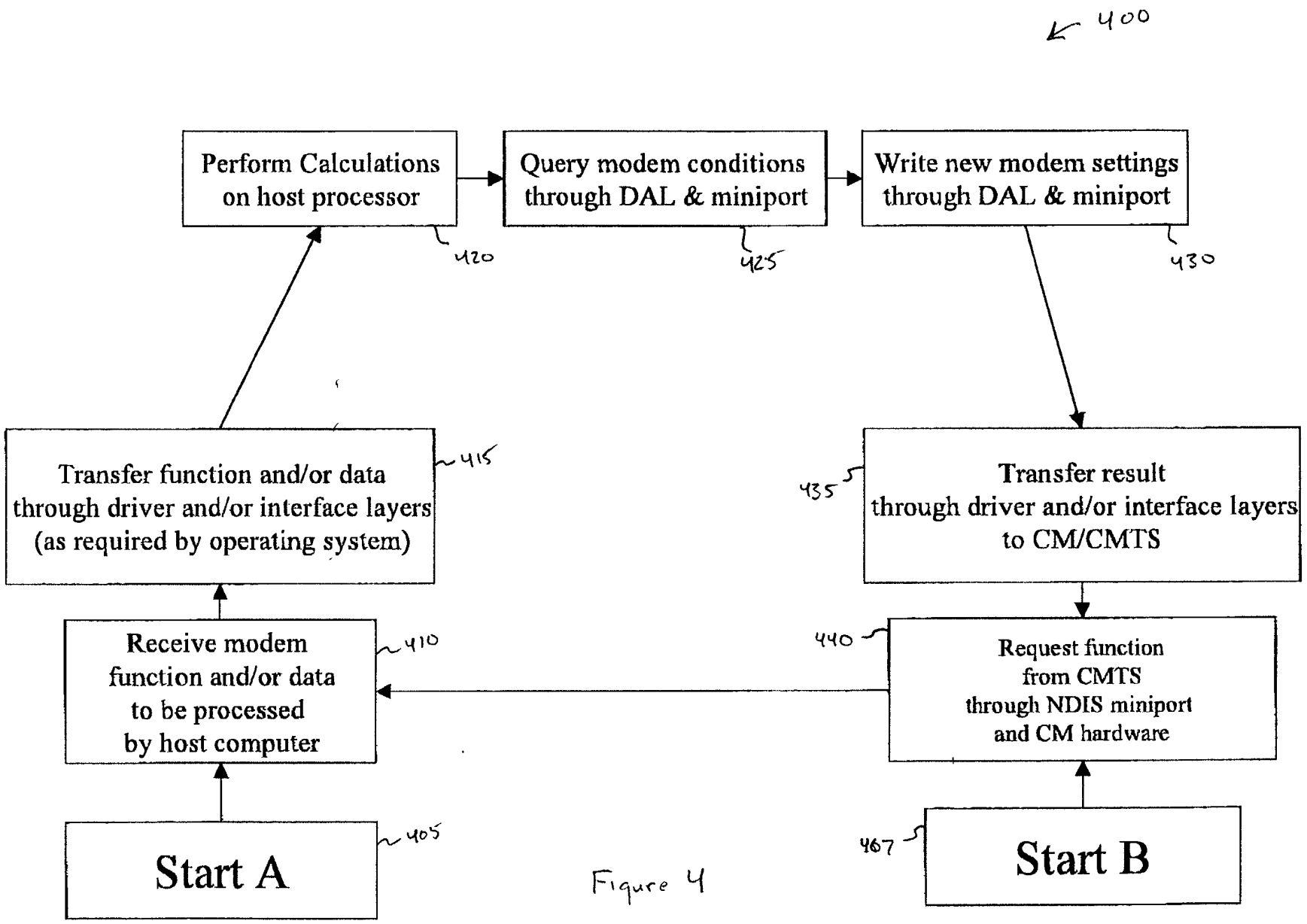
400
Perform Calculations on host processor
420
Query modem conditions through DAL & miniport
425
Write new modem settings through DAL & miniport
430
Transfer function and/or data through driver and/or interface layers (as required by operating system)
415
Transfer result through driver and/or interface layers to CM/CMTS
435
Receive modem function and/or data to be processed by host computer
410
Request function from CMTS through NDIS miniport and CM hardware
440
Start A
405
Start B
467

Figure 4

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention IMPLEMENTING CABLE MODEM FUNCTIONS ON A HOST COMPUTER, the specification of which:

[x] is attached hereto.
[] was filed on _____ as Application Serial No._____and was amended on _____.
[] was described and claimed in PCT International Application No. _____ filed on _____ and as amended under PCT Article 19 on _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §119(e)(1) of any United States provisional application(s) listed below:

U.S. Serial No.	Filing Date	Status

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Serial No.	Filing Date	Status

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

Country	Application No.	Filing Date	Priority Claimed
			[] Yes [] No
			[] Yes [] No

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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